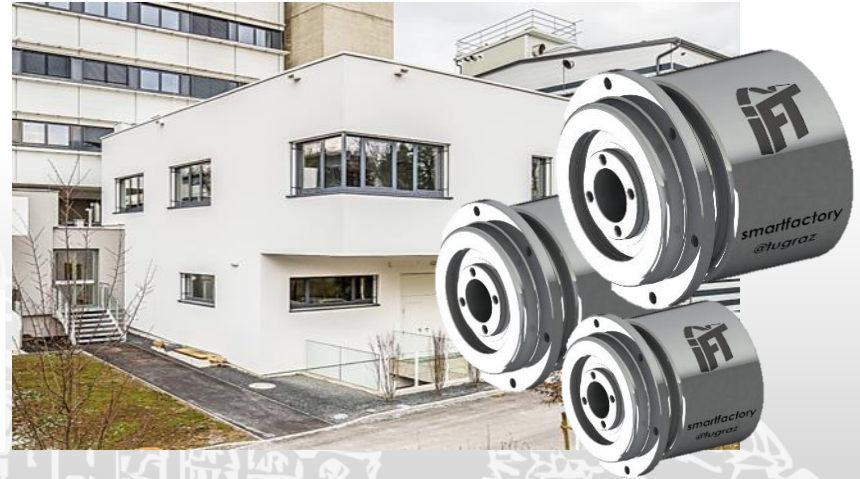


**smartfactory@tugraz**

LERNFABRIK FÜR AGILE UND DATENSICHERE FERTIGUNG



# Digitalization for Batch Size One Production of Robot Gear Boxes – Realistic Scenario or Illusion

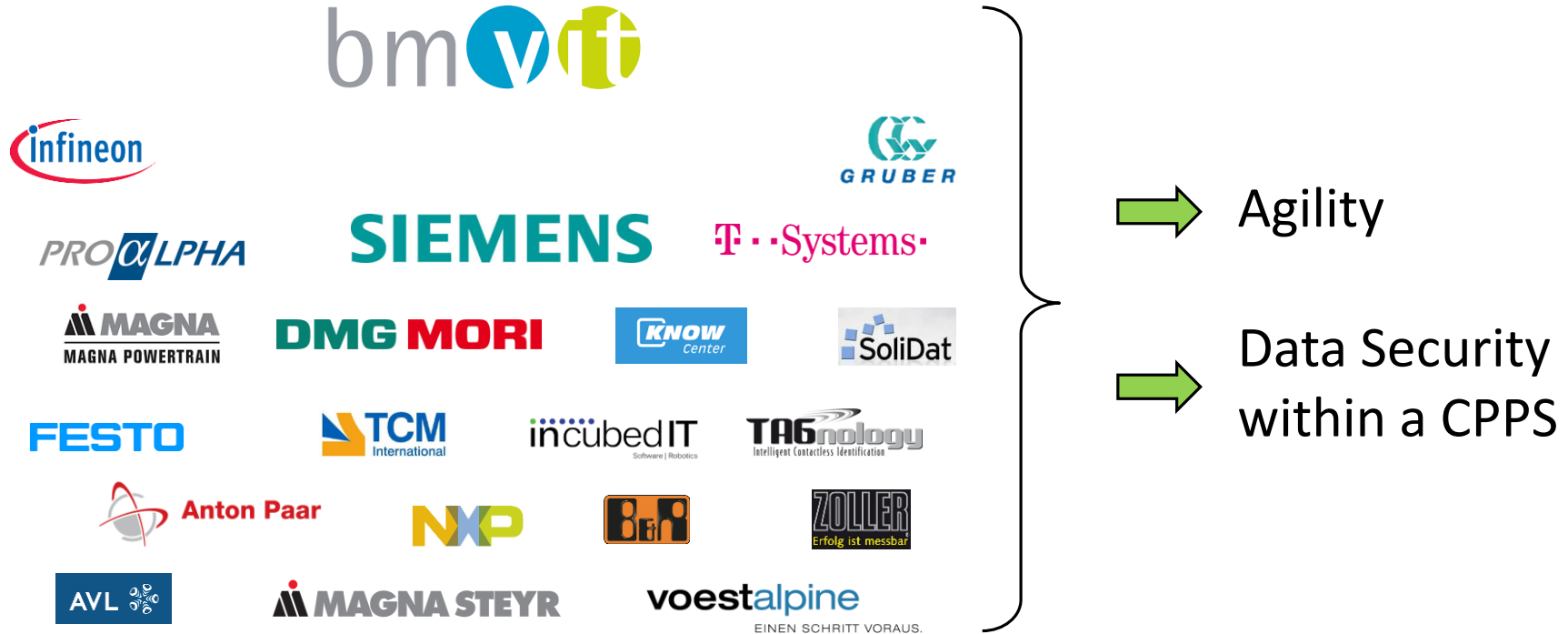
Prof. Franz Haas / Prof. Rudolf Pichler / Michael Michelitsch

07.06.2018

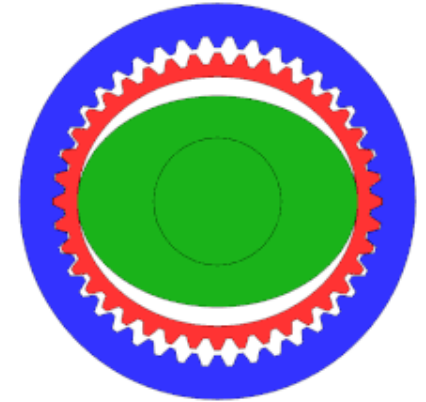
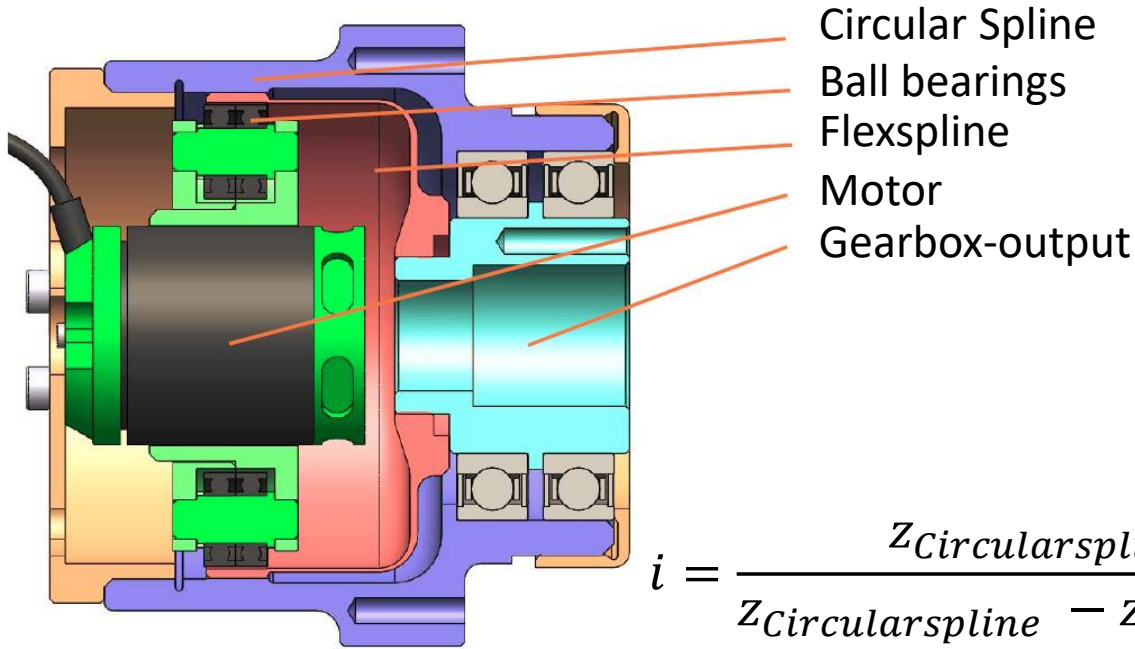
# Agenda

- Introduction
- Industry 4.0 pilot factory: [smartfactory@tugraz](mailto:smartfactory@tugraz)
- Case Study: robot [smartgear](#)
- Parametric design
- Workflow and factory concept
- Sensors and sensor networks as I4.0 enablers
  - Milling temperature
  - Electrical power
  - Grinding force
- Next steps and Conclusion

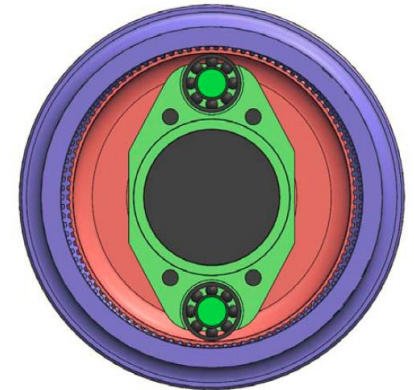
# Industry 4.0 pilot factory: smartfactory@tugraz



# Case Study: robot smartgear

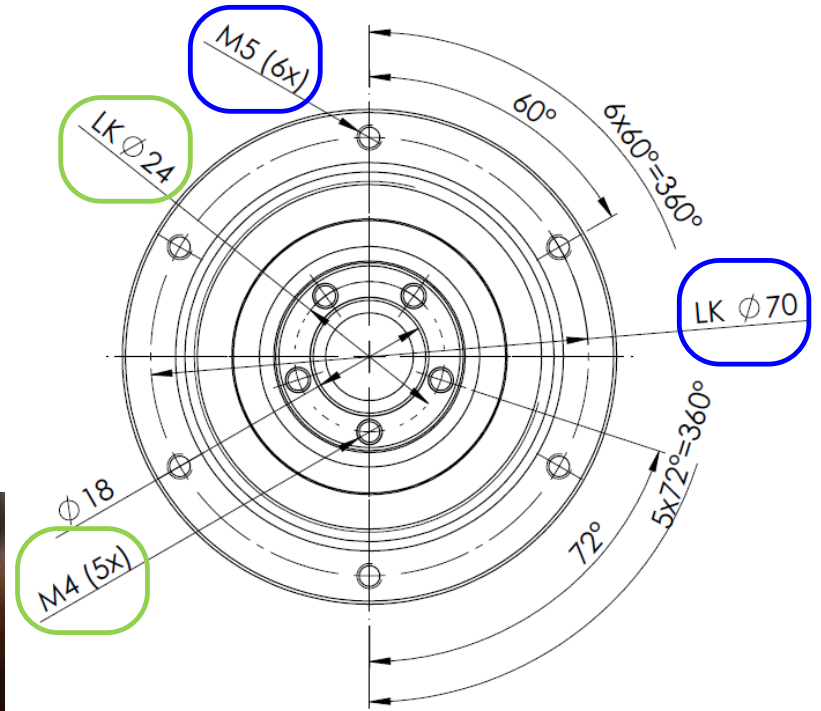
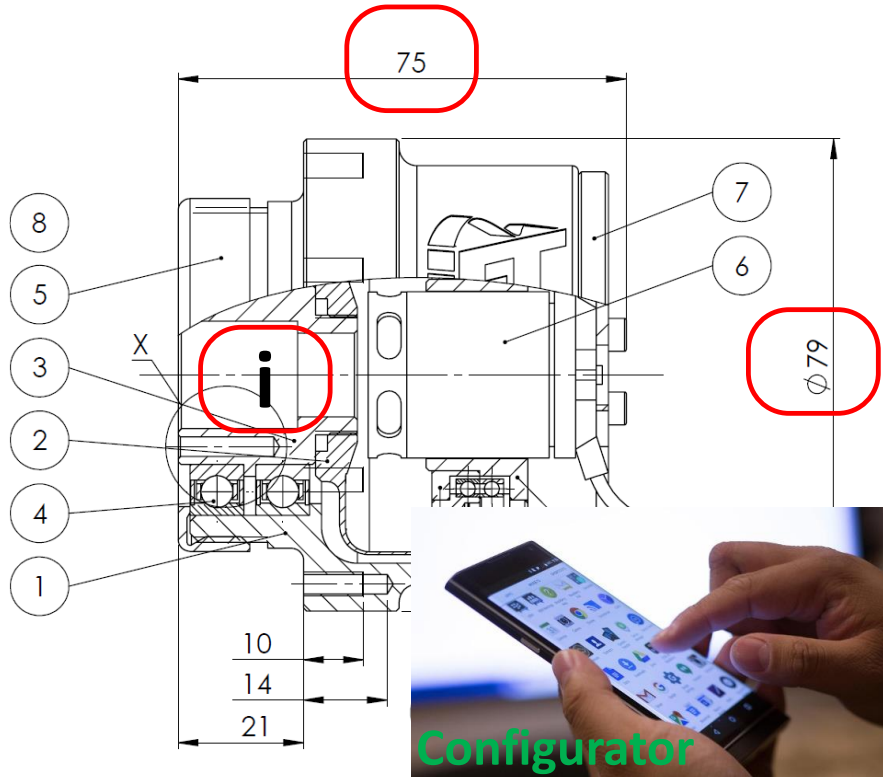


[https://de.wikipedia.org/wiki/Harmonic\\_Drive#/media/File:HarmonicDriveAni.gif](https://de.wikipedia.org/wiki/Harmonic_Drive#/media/File:HarmonicDriveAni.gif)



$$i = \frac{Z_{Circularspline}}{Z_{Circularspline} - Z_{Flexspline}}$$

# Parametric Design

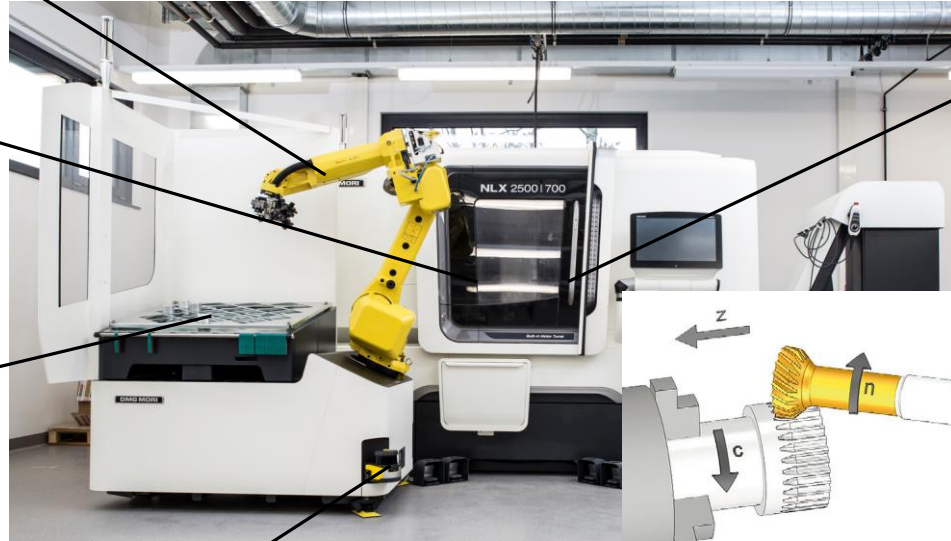


# Machining Center (Core machine)

Industrial robot

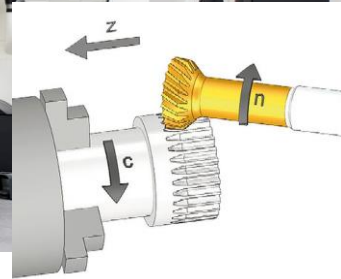
1<sup>st</sup> Spindle

Raw parts



Safety camera

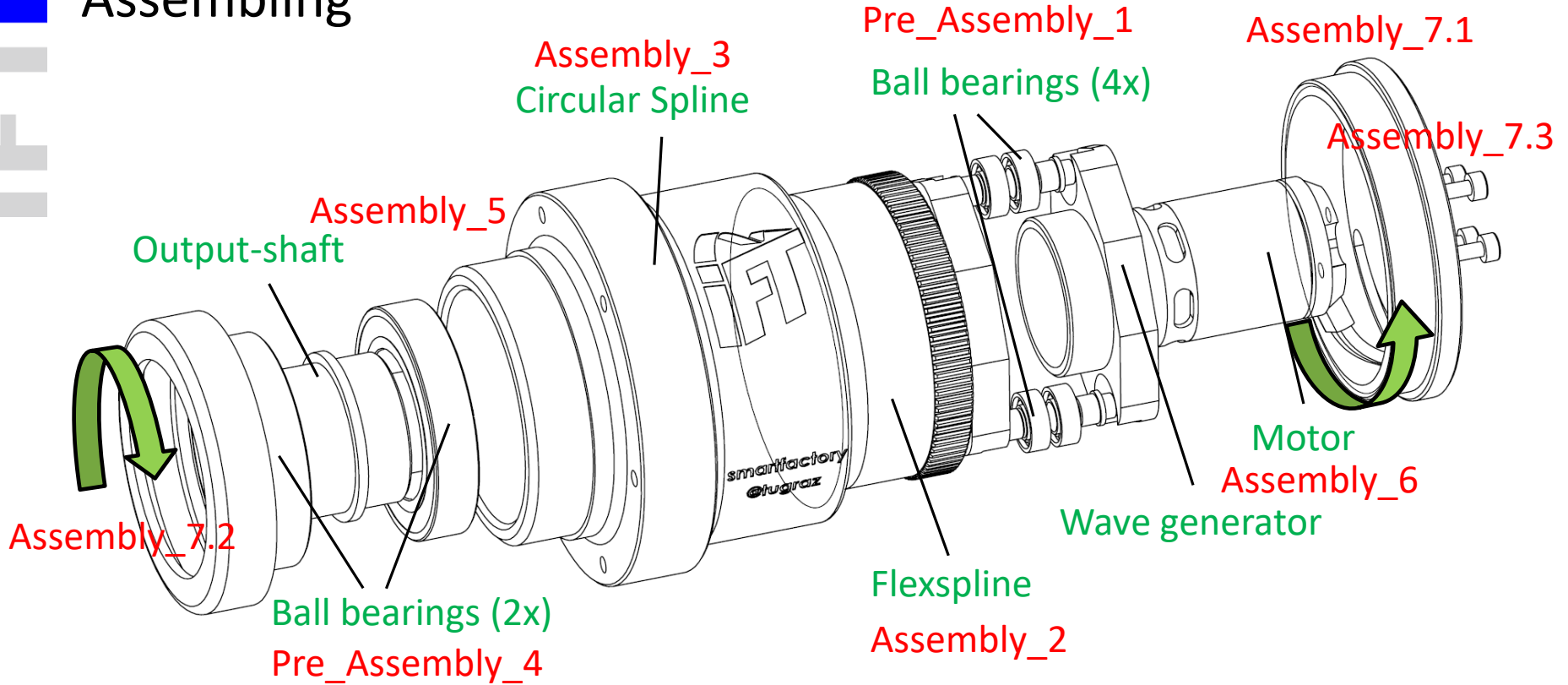
2<sup>nd</sup> Spindle



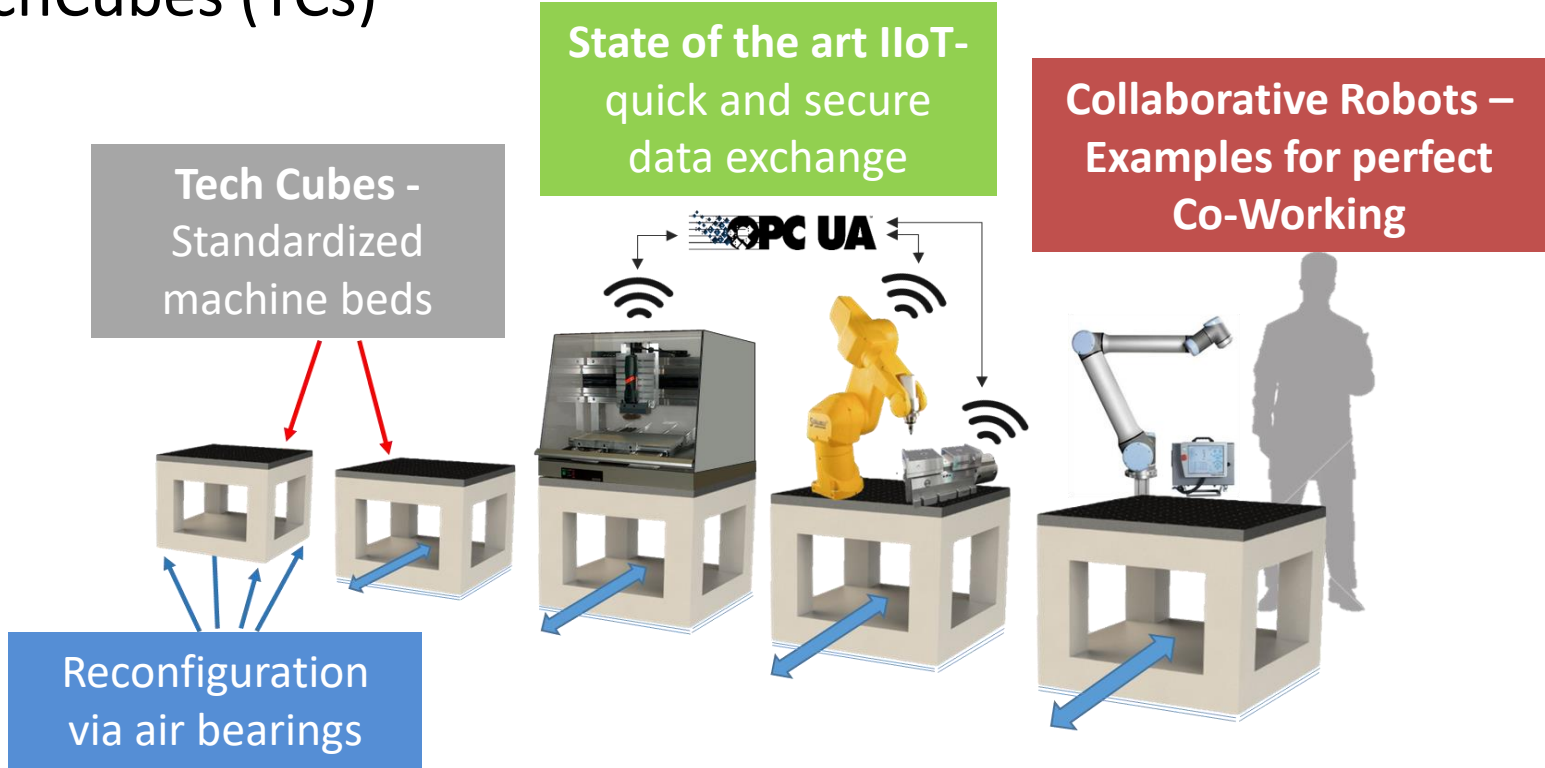
Gear skiving

<https://www.wto-tools.com/en-us/products/turning-centers/gear-skiving/>

# Assembling

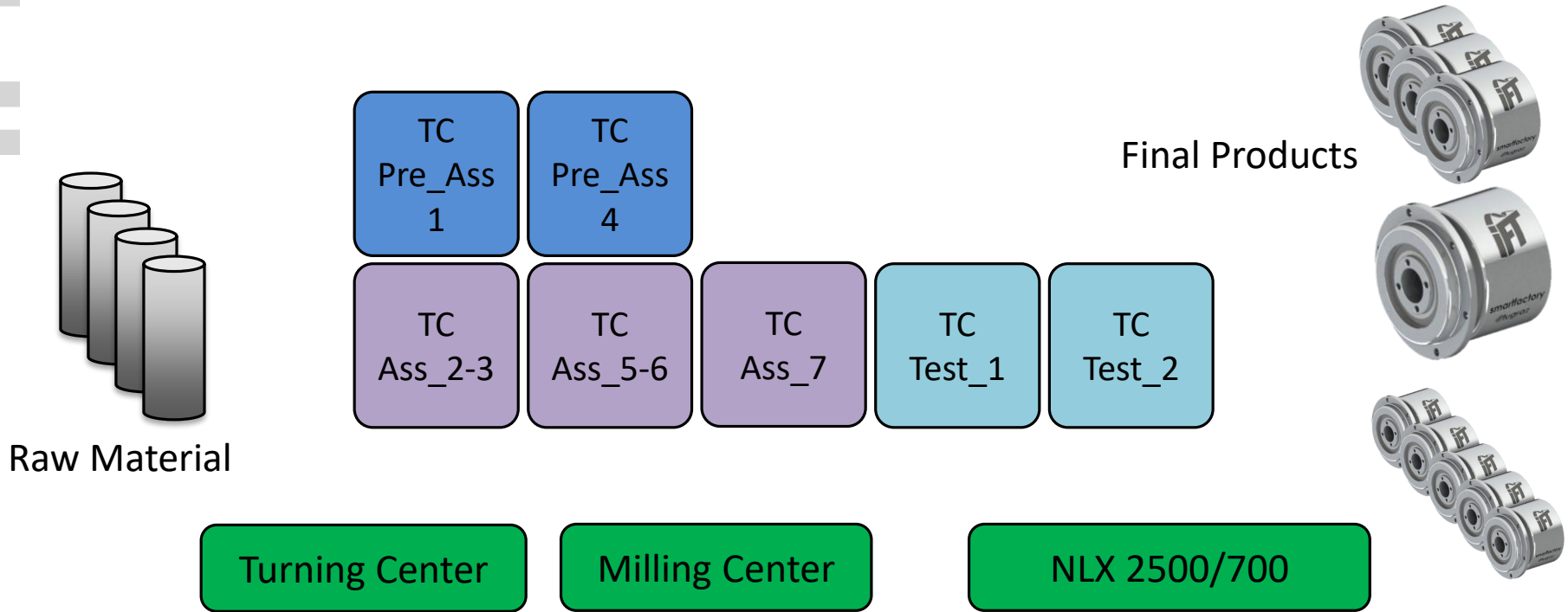


# TechCubes (TCs)

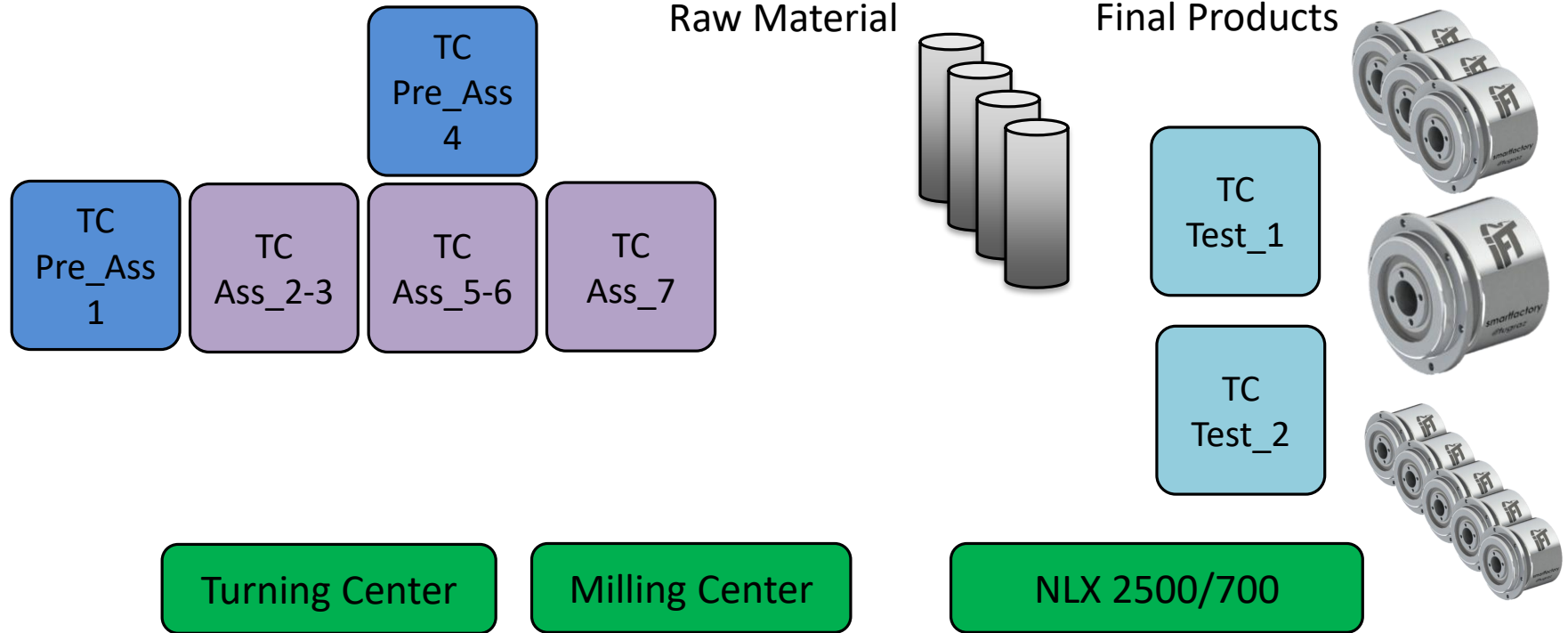




# Workflow and factory concept with TechCubes (TC)



# Workflow and factory concept with TechCubes (TC)

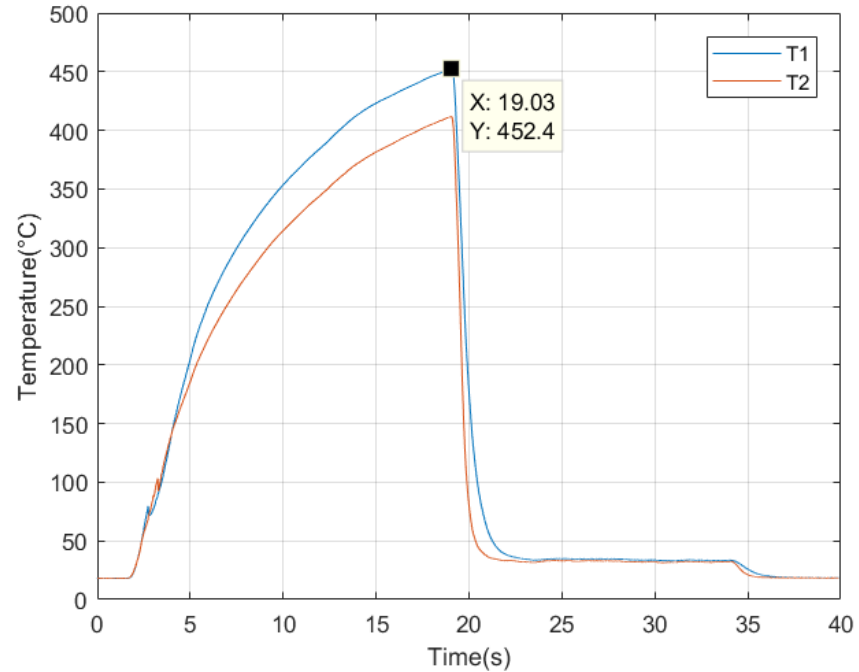
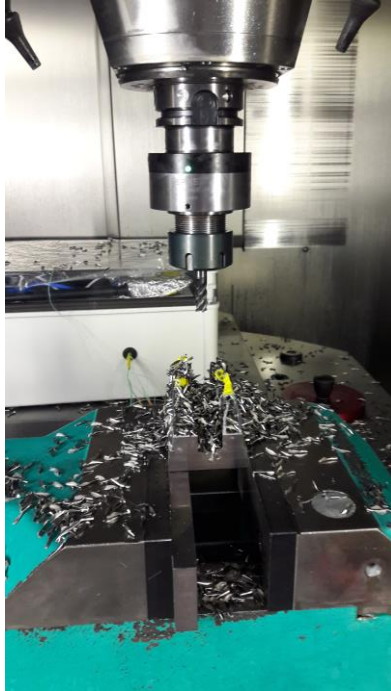


# Process/value chain needs intelligent systems

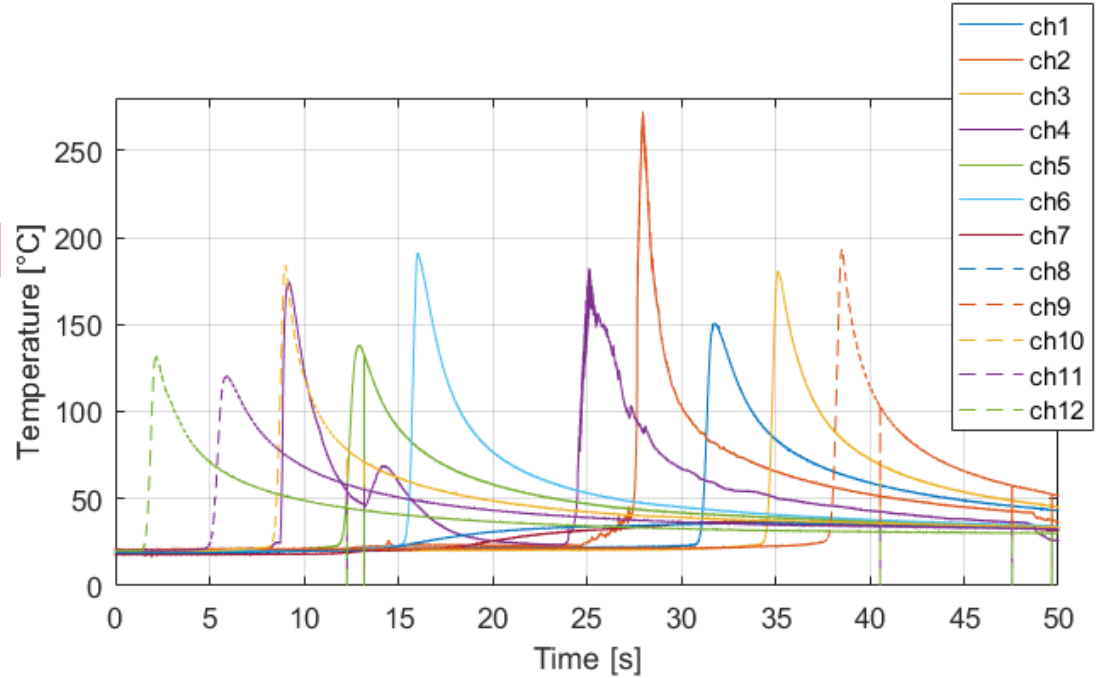
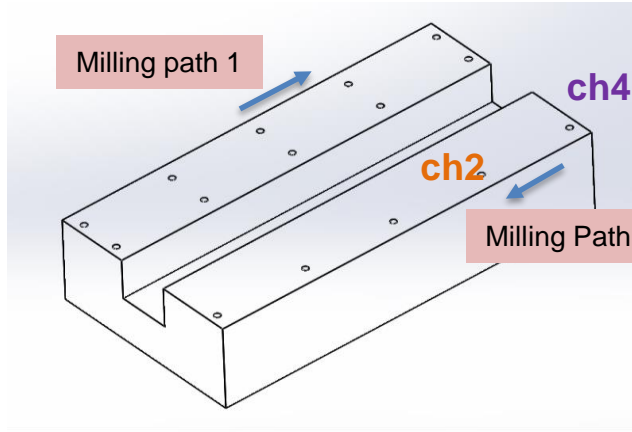


# Sensor Networks for Artificial Intelligence

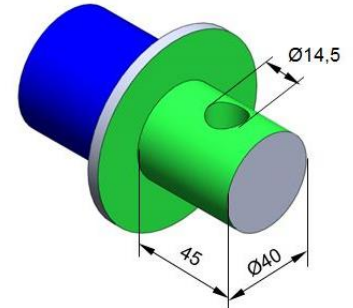
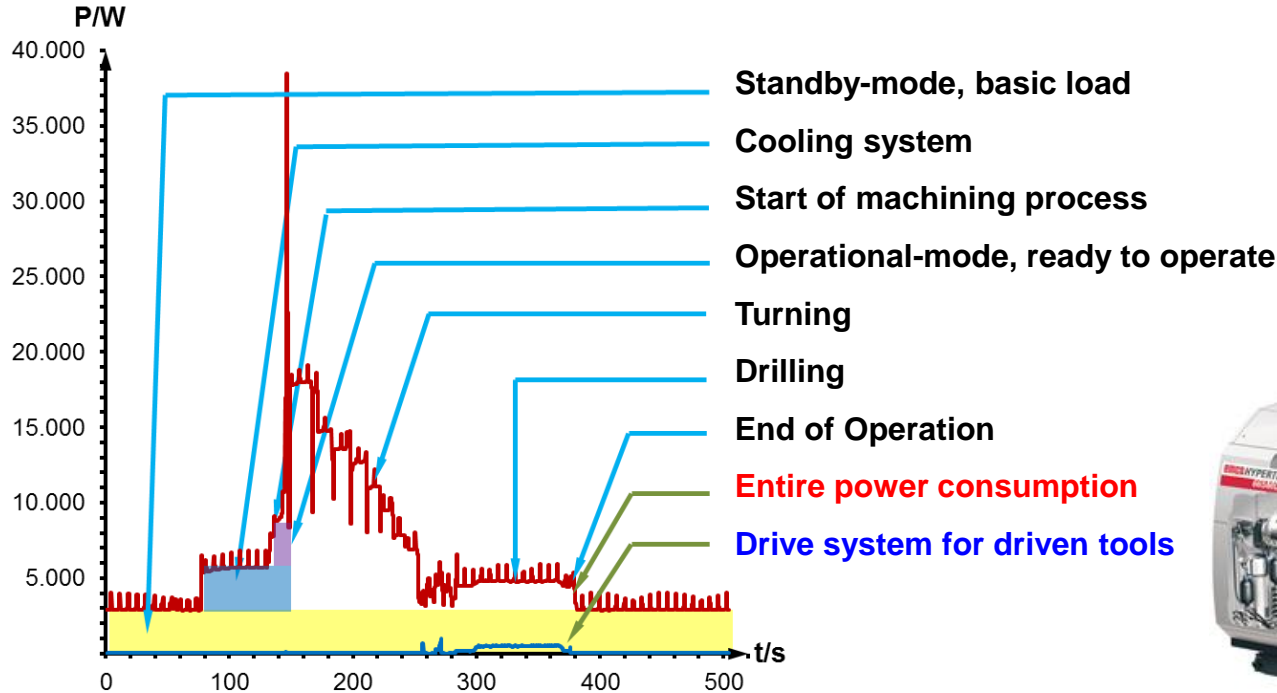
# Milling temperature



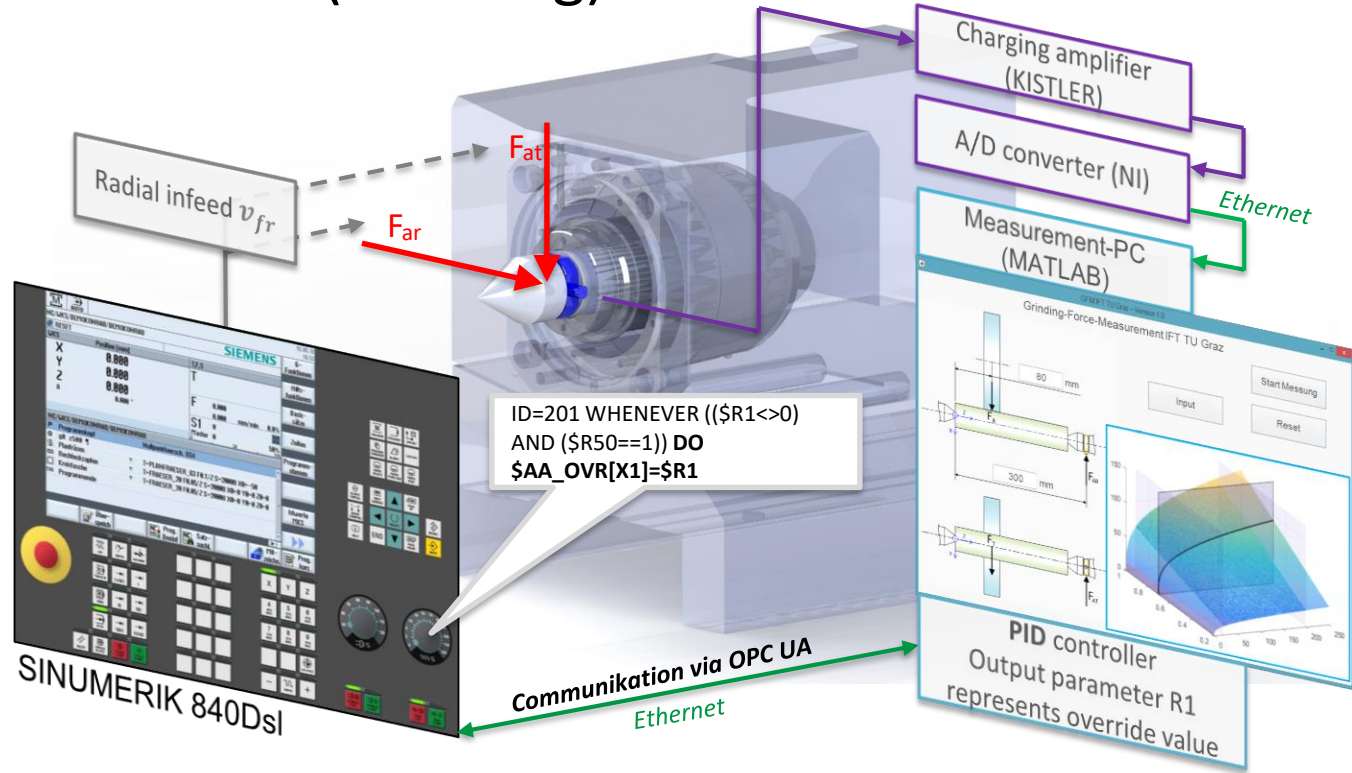
# Machining Temperature as Key Performance Indicator



# Power Analysis of Machine Tools

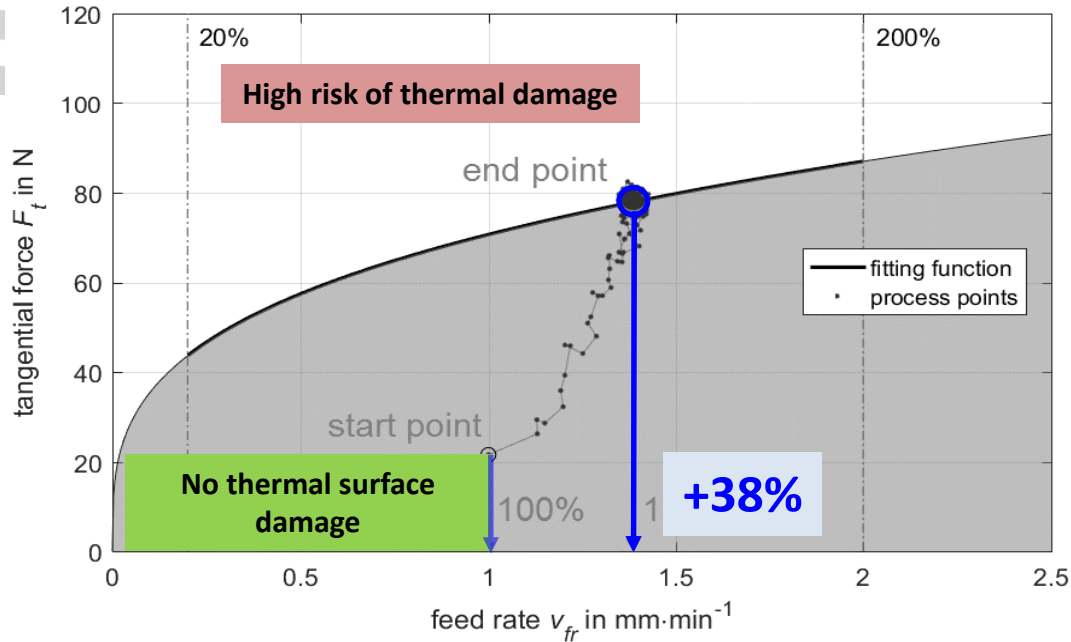


# Adaptive Control (Grinding)

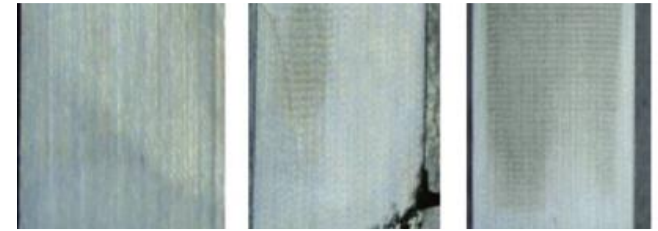




# Improvements



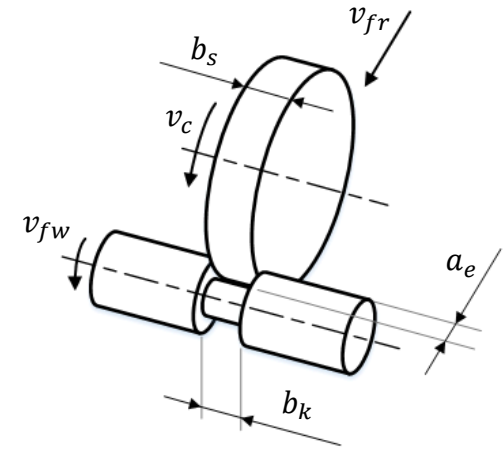
Thermal surface damage



No Impact

Low

Medium



# Conclusion

What we need?

- Modular Construction
- Parametric Description
- Modern Machinery
- TechCubes for assembling
- Sensor networks
- Not to many restrictions at the beginning.
- Spirit and motivation

